2A94-45

REPORT TO THE ALASKA BOARD OF FISHERIES ON THE STOCK COMPOSITION OF SOCKEYE SALMON CATCHES MADE BY TEST FISHERIES IN NAKNEK-KVICHAK DISTRICT, 1992, AND MIDDLE BLUFF AREA, 1993-1994.

By: Drew L. Crawford
James D. Miller
Beverly A. Cross

Regional Information Report[1] No. 2A94-45

Alaska Department of Fish and Game
Division of Commercial Fisheries Management and Development, Central Region
333 Raspberry Road
Anchorage, Alaska 99518-1599

December 1994

[1] The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished divisional reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series may contain preliminary data; this information may be subsequently finalized and published in the formal literature. Consequently, these reports should not be cited without prior approval of the author or the Division of Commercial Fisheries Management and Development.

AUTHORS

Drew L. Crawford is Region II Bristol Bay Research Biologist for the Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, 333 Raspberry Road, Anchorage, AK 99518.

James D. Miller is Region II Bristol Bay Research Biologist for the Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, 333 Raspberry Road, Anchorage, AK 99518.

Beverly A. Cross is Region II Bristol Bay Research Project Leader for the Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, 333 Raspberry Road, Anchorage, AK 99518.

ACKNOWLEDGEMENTS

We would like to thank all Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development employees who acted as observers aboard the test fish vessels. We would also like to thank those commercial fishermen who participated in the stock identification test fisheries in the Naknek-Kvichak District in 1992 and in the Middle Bluff area in 1993 and 1994. We would like to thank Trev Beeston and Ivan Fox of Nelbro Fisheries for their logistical support and use of their facilities.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF APPENDICES

LIST OF APPENDICES

ABSTRACT

Stock composition estimates were made for Bristol Bay sockeye salmon, *Oncorhynchus nerka*, caught in test fisheries in Naknek-Kvichak District in 1992 and the Middle Bluff area in 1993-1994, using scale pattern analysis. Test fishing was conducted in seven study areas located in the southern and western section of the Naknek-Kvichak commercial fishing district in 1992. Test fishing was conducted in four study areas along the eastern shore of Kvichak Bay near Middle Bluff in 1993 and 1994. Scales collected from sockeye salmon caught by the test fishery were classified to river of origin using linear discriminant function analysis. Stock identification models were based on scale growth measurements from sockeye salmon spawning populations in Kvichak, Naknek, Egegik, and Ugashik Rivers. Stock composition estimates varied considerably among study areas and through time. Stock mixing within the Naknek-Kvichak District and the Middle Bluff area is very complex and varies from year to year.

KEY WORDS: Sockeye salmon *Oncorhynchus nerka*, Bristol Bay, Naknek-Kvichak District, Middle Bluff-Kvichak Bay, test fishing, scale pattern analysis, stock composition

INTRODUCTION

Commercial fishing districts in Bristol Bay are located near the mouths of major sockeye salmon spawning rivers (Figure 1). Historically, catches were assumed to be comprised of salmon returning to spawn within those rivers (Minard and Meacham 1987). Past tagging studies (Straty 1975), abundance trends of Kvichak River sockeye salmon (Eggers and Rogers 1987), and scale pattern analyses of east side district catches (Burns 1991, Cross et al. 1989a, Fried and Yuen 1985, Stratton et al. 1991, Stratton and Miller 1994) have suggested that east side sockeye salmon stocks are mixed in all east side districts. Concerns over high rates of interception of non-Egegik River stocks in the Egegik District prompted the Alaska Department of Fish and Game (ADF&G) to initiate a test fishery in 1988 (Cross and Stratton 1989). The purpose of the test fishery was to collect sockeye salmon scales for stock identification studies to gain a better understanding of the degree of stock mixing within the Egegik District. Additional test fisheries were continued in the Egegik District from 1989-1991 (Cross et al. 1989b, Miller et al. 1991a and 1991b).

In 1992 ADF&G moved the test fishery to the Naknek-Kvichak District in order to gain a better understanding of stock mixing within the Naknek Section. Traditionally, fishery managers have used commercial fishery openings in the Naknek Section to harvest Naknek River runs and minimize the harvests of Kvichak River runs. However, recent commercial catch composition studies showed that fish bound for the Kvichak River comprised an average of 40% of the Naknek Section commercial salmon catches (B.L. Stratton, Alaska Department of Fish and Game, Anchorage, personal communication). The objectives of the 1992 test fishery were to: (1) estimate sockeye salmon stock composition within specific study areas; and (2) determine if there were spatial or temporal trends in the interception of non-Naknek (Kvichak, Egegik, and Ugashik) River sockeye salmon. An additional objective was to investigate the feasibility of using a test fishery to better delineate stock mixing in Naknek Section.

Recent large salmon runs through the Middle Bluff area of Kvichak Bay have generated many new proposals to the Board of Fisheries to increase the size of fishing districts and/or establish a corridor for fishing between the Egegik and Naknek-Kvichak Districts. Therefore in 1993 and 1994, ADF&G shifted their test fishery to the Middle Bluff area, to collect sockeye salmon scales for stock identification studies to better understand stock mixing between these two fishing districts. The objectives of the 1993 and 1994 test fishery at Middle Bluff were to: (1) estimate sockeye salmon stock composition within specific study areas; and (2) determine if there were spatial or temporal trends in the stock composition test fishery catches.

METHODS

Test Fishing

For all study years (1992-1994) commercial fishermen were contracted to catch sockeye salmon from specified areas within the Naknek-Kvichak District or the Middle Bluff area during commercial closures. Gill nets used for test fishing were provided by the fishermen and ranged in mesh size from 5 in to 5 1/4 in. An ADF&G employee was aboard each test fish boat to record data and sample the catch. The sampling goal was to collect 600 sockeye salmon scales per study area per date.

Generally, three boats were sent out to collect samples every day test fishing occurred. To obtain a more representative sample of the fish present within an area, we tried to have two boats fish the same study area each day.

The ADF&G observer recorded the following information for each drift: date, time, tide stage, Loran C coordinates when net was deployed, Loran C coordinates when net retrieval was complete, wind direction, and number of salmon caught by species. The observer also recorded gear length and fishing times in order to calculate mean fishing time and estimate relative indices of abundance (Appendix A).

1992 Naknek-Kvichak District Study Areas

Test fishing was conducted in seven study areas (Figure 2) from 21 June through 12 July. Two drift gill net boats fished, one in each area, every day of operation. Study area A was located below Libbyville at the north boundary between the Naknek and Kvichak Sections (Loran C line 9990-Y-32350; Table 1; Figure 2). Study area B was below Loran C line 9990-Y-32365 just above the mouth of the Naknek River. Study areas C and D were located between the mouth of the Naknek River and the south boundary of the Naknek-Kvichak District at the Johnson Hill line (Loran C line 9990-Y-32430). Study areas E, F, and G were located along the Johnson Hill line with study area E in the Kvichak Section, study area F overlapping the east-west boundary between the two sections, and study area G located on the south boundary of the Naknek Section. In all instances, boats were free to move in an east-west direction within each study area. Study areas were chosen to test the hypothesis that interception of non-Naknek sockeye salmon, especially those bound for the Kvichak River, was greater in study areas located a greater distance from the Naknek River.

In 1992 test fishing was also conducted in three additional study areas in the Kvichak Section, however due to digitizing time constraints these data were not analyzed.

1993-1994 Middle Bluff Study Areas

Test fishing was conducted in four study areas (Figure 3). Test fishing occurred from 23 June through 12 July in 1993 and from 19 June through 12 July in 1994. Study areas A, B, C, and D were located in the Middle Bluff area between Big Creek on the south (Loran C lines 9990-Y-32565) and Big Flat on the north (Loran C line 9990-Y-32510; Table 1; Figure 3)). The shoreline was the eastern boundary of each of these study areas and the western boundary was along Loran C line 9990-Z-45135 for study areas A-C and along Loran C line 9990-Z-45130 for study area D.

Study areas were chosen to test the hypothesis that interception of sockeye salmon bound for all east side Bristol Bay rivers occur in this area. Middle Bluff, just north of Egegik District, is believed to be a milling area for sockeye salmon returning to all east side districts (Straty 1975, Pennoyer and Nelson 1967). It is thought that sockeye salmon aggregate in the Middle Bluff area and move below the north boundary of Egegik District with outgoing tides. Test fishing was scheduled during ebb tides to simulate commercial fishing patterns.

Estimation of Stock Composition

Age Determination

Scales were mounted on gummed cards and impressions made in acetate. Scale impressions were examined with a microfiche reader at 30x, and ages were determined from circuli patterns (Mosher 1968). We recorded ages in European notation (e.g., age-2.2): numerals preceding the decimal refer to the number of freshwater annuli and numerals following the decimal refer to the number of marine annuli (Koo 1962). Total age from time of egg deposition (brood year) is the sum of these numbers plus one.

Measurement Of Scale Patterns

Scale impressions were projected at 100x onto a digitizing tablet. Distances between circuli (growth rings) were measured, and the number of circuli were recorded for the following growth zones: (1) first freshwater annulus (all ages); (2) second freshwater annulus (age-2.2); (3) plus growth (all ages), if present; and (4) first marine annulus (all ages). For 3-ocean sockeye salmon, we also measured the total width of the second ocean annulus. Up to 109 variables were computed from distance measurements and circuli counts (Appendix B.1). Because of time and budget constraints, only scale patterns of age-1.3 sockeye salmon in 1992 and age-2.2 sockeye salmon in 1993 and 1994 were measured. The 1.3-age

class represented 29% of the sockeye salmon caught by the test fishery in 1992, and the 2.2-age class represented 46% and 41% of the 1993 and 1994 test fish catches, respectively.

Construction Of Stock Identification Models

Linear discriminant function analysis (LDF; Fisher 1936) of scale measurements was used to classify sockeye salmon caught in the study areas to river of origin. This technique identified sockeye salmon stocks based on scale growth differences. Scales collected from sockeye salmon captured at the heads of Kvichak, Naknek, Egegik, and Ugashik Rivers (known origin samples) were used to build classification models. Two hundred scales per river system and age group (age-1.3 in 1992 and age-2.2 in 1993 and 1994), weighted by run through time, were measured. Scale variables which provided the greatest discrimination among stocks were included in the models.

Classification Of Test Fish Samples

Scales collected from test fish catches (unknown origin samples) were classified to river of origin using the LDF models. One hundred scales per age group (age-1.3 in 1992; age-2.2 in 1993 and 1994) were measured from each test fish area and date sampled. Normally, test fish catches would be classified using a four-way model. However, misclassification between some stocks during each year resulted in the pooling of stocks and the production of three-way models. Test fish catches were initially classified using the three-way models. If the estimated contribution of one or more stocks was zero, then the catch was reclassified with a model which excluded that stock or stocks. Point estimates were adjusted for misclassification error using the procedure of Cook and Lord (1978). The 90% confidence intervals around the stock estimates were computed using the procedure of Pella and Robertson (1979).

Kvichak and Ugashik River stocks were pooled in 1992 because their growth patterns were similar. Since the probability of catching Ugashik River sockeye salmon in Naknek-Kvichak District was lower than the probability of catching Kvichak River sockeye salmon in the Naknek-Kvichak District, it was not possible to divide these two stocks using age composition.

In 1993 and 1994, similar growth patterns between Kvichak and Naknek stocks resulted in the pooling of these two stocks for both years. The estimated catch of Kvichak-Naknek sockeye salmon was divided between Kvichak and Naknek River based on each river's escapement age composition.

Stock composition estimates for sockeye salmon of other age groups (ages other than -1.3 in 1992 and -2.2 in 1993-1994) were estimated by combining scale pattern analysis results with escapement age composition data. Detailed descriptions of methods used to estimate stock composition for other age groups can be found in Stratton and Miller (1994). Two assumptions were made using this

technique: (1) age composition of a stock was the same in both catch and escapement; (2) exploitation rate was equal for all age groups.

Calculation Of Mean Percent Abundance By Stock

In order to compare overall catches among areas it was necessary to calculate the mean percent abundance (MA) of each stock for each area. MA by stock for each area in a given year was calculated using stock composition estimates and abundance indices for that area and date (Appendix C). We were able to compare catches of each stock among study areas for the entire study period by combining relative abundance with stock proportion estimates.

RESULTS AND DISCUSSION

Test Fishing

Test fishing occurred regularly during fishery closures throughout the 1992, 1993, and 1994 commercial salmon fishing seasons. The initial test fishing strategy was to have test fish boats fish in adjacent study areas, however due to variability of fish abundance and the availability of test fishermen this test fishing strategy proved to be impractical and it was seldom employed.

Test fishing in 1992 Naknek-Kvichak District Areas occurred from 21 June to 12 July. Test fish catch samples from the following dates were selected for analysis: 21, 24, 25, 26, and 28 June; 1, 2, 8, 9, and 12 July (Appendix D.1). Total number of sockeye salmon scales sampled by ADF&G observers was 7,497.

In 1993, test fishing was conducted in the Middle Bluff area from 23 June to 12 July. Test fish catch samples from the following dates were selected for analysis: 23, 24, 28, and 30 June; 6, 8, 9, and 11 July (Appendix D.2). Total number of sockeye salmon scales sampled by ADF&G observers was 18,968.

In 1994, test fishing in the Middle Bluff area occurred from 19 June to 12 July. Test fish catch samples from the following dates were selected for analysis: 26, 27, and 28 June; 1, 2, and 10 July (Appendix D.3). Total number of sockeye salmon scales sampled by ADF&G observers was 11,416.

Stock Identification Models

In 1992, scales from Kvichak and Ugashik River age-1.3 sockeye salmon had similar growth patterns which resulted in considerable misclassification. Therefore, Kvichak and Ugashik River sockeye salmon scale samples were combined in a three-

way model (Kvichak-Ugashik, Naknek, Egegik). Overall accuracy of the age-1.3 three-way model was 74.7% (Appendix E.1). Classification of Egegik River sockeye salmon was the most accurate (82.3%). Classification accuracy for Kvichak-Ugashik (72.5%) and Naknek (69.4%) River sockeye salmon stocks was similar.

In 1993 and 1994, scales from Kvichak and Naknek River age-2.2 sockeye salmon had similar growth patterns which resulted in considerable misclassification. Therefore, Kvichak and Naknek River sockeye salmon scale samples were combined in a three-way model (Kvichak-Naknek, Egegik, Ugashik) for each of these years.

In 1993, overall accuracy of the three-way age-2.2 model was 72.4% (Appendix E.2). Scales of Ugashik and Egegik River age-2.2 sockeye salmon could be distinguished from all other stocks because of their corresponding very small and very large freshwater growth. Therefore, estimates of Ugashik River (77.5%) and Egegik River (76.3) stocks contributions were the most accurate. Classification accuracy for Kvichak-Naknek (63.3%) River sockeye salmon was lower.

In 1994 the three-way age-2.2 model had an overall accuracy of 75.7% (Appendix E.3). Ugashik River sockeye salmon had the highest classification accuracy (81.1%), while the Kvichak-Naknek River combined stock and the Egegik River stock had the lower classification accuracy (73.0%). The Kvichak-Naknek River combined stock misclassified to both Egegik and Ugashik River stocks.

Test Fish Stock Composition

Readers are cautioned not to expand test fishery stock composition estimates directly to the commercial fishery: the test fishery was designed to describe stock composition within specific locations and time, not to quantify actual abundance. Therefore, we cannot estimate actual numbers of sockeye salmon by stock within an area, only the proportion of the daily abundance index represented by each stock in a specific test fish catch.

1992 Naknek-Kvichak District Study Areas

There were no apparent daily trends in stock composition in the 1992 test fishery (Figure 4-5, Appendix F.1) based on limited daily strata. The percentage of non-Naknek sockeye salmon were greater in Area A on each of the two sampling dates. The catch of non-Naknek sockeye in Area A increased from 55% in late June to 62% in early July. Test fish catches of non-Naknek sockeye in Area B on three sampling dates ranged from 54% in late June to 74% in early July. The percentage of non-Naknek sockeye salmon in Area C comprised 92% of the testfish catch in late June and dropped to 47% in early July. Area D was only sampled once and the catch from this area on July 11 was predominantly (68%) Naknek sockeye salmon. Area E was also sampled only once and the percentage of Naknek sockeye salmon on July 8 was 69%. Area E was the only study area that was located entirely within the Kvichak Section of the Naknek-Kvichak District. Testfish catches of non-Naknek sockeye salmon in Area F on two sampling dates decreased from 74% to 67%

in late June. The percentages of non-Naknek sockeye salmon in Area G comprised 70% of the catch in late June and increased to 75% in early July.

No spatial or temporal trends were evident in 1992 stock composition estimates (Table 2, Appendix F.1). Five of six study areas that were located primarily in the Naknek Section (Areas A, B, C, F, and G) had higher mean percent abundances of non-Naknek stocks than Naknek River stocks in their testfish catches (Figure 6). The two study areas with the highest percentages of Naknek River sockeye salmon were Areas D and E. Naknek River stocks composed 69% of the catch from Area D and 76% of the catch from Area E. Area D is located in the heart of the Naknek Section along the east shore of Kvichak Bay below the mouth of the Naknek River. Area E is located outside the southern boundary of the Naknek Section in the southwest corner of the Kvichak Section. The high variability of the percent composition of sockeye salmon catch by study area and stock suggest much stock intermingling within the Naknek Section and along the south boundary line (Loran C 9990-Y-32430).

The results of the 1992 Naknek-Kvichak District stock identification testfishing study only represent the findings from one year of data. This study took place during a year in which 10.0 million fish returned to Kvichak River (below 1983-1992 average of 13.0 million) and 5.0 million fish returned to Naknek River (slightly above 1983-1992 average of 4.7 million; ADF&G 1993). Stock compositions that were found in the Naknek-Kvichak District study areas in 1992 would probably differ from other years as the relative run sizes of the Kvichak and Naknek Rivers change.

1993-1994 Middle Bluff Study Areas

Test fishing was conducted in Middle Bluff Areas A, B, C, and D in 1993 and 1994.

The spatial and temporal trends observed in the 1993 and 1994 Middle Bluff testfish catches of Egegik River versus non-Egegik River sockeye salmon based on limited daily strata are presented in Figures 7 and 8.

In 1993, catches of Egegik River sockeye salmon predominated in all Middle Bluff study areas on all dates sampled (Figure 7, Appendix F.2). The percent composition of Egegik River stocks ranged from 64% to 86% with a mean of 79%. Non-Egegik sockeye salmon stocks were most numerous in Areas A and B. Peak daily catches of non-Egegik sockeye salmon occurred on July 8 in Area A (22% Kvichak, 9% Naknek, 1% Ugashik) and July 11 in Area B (20% Ugashik, 10% Kvichak, 6% Naknek).

In 1994, catches of Egegik River sockeye salmon predominated in Middle Bluff study areas A, B, and C on all dates sampled (Figure 8, Appendix F.3). The percent composition of Egegik River stocks in these areas ranged from 73% to 98% with a mean of 89%. Non-Egegik sockeye salmon stocks were most numerous in Area D and B. Peak daily catches of non-Egegik sockeye salmon occurred on July 10 in Area D (57% Kvichak, 14% Naknek, 4% Ugashik) and July 2 in Area B (23% Kvichak, 5% Naknek, 0% Ugashik).

From 1993 to 1994, Area A catches of Egegik River sockeye salmon increased from 77.4% to 95.9% (Table 3; Figure 9). The percent of Kvichak River sockeye salmon varied from 14.2% in 1993 to 3.5% in 1994. Naknek and Ugashik River sockeye salmon composed less than 7% and 2% respectively each year. Kvichak River made up the largest non-Egegik River component of the Area A catch in 1993 and 1994.

In Area B, the percent of Egegik River sockeye salmon caught increased from 64.3% in 1993 to 73.6% in 1994 (Table 3; Figure 9). Kvichak River sockeye salmon catches increased from 10.1% in 1993 to 21.7% in 1994. Percentages of Naknek River sockeye salmon were small both years, and ranged from 5.8% in 1993 to 4.7% in 1994. Ugashik River sockeye salmon varied from a high of 19.8% in 1993 to a low of 0.1% in 1994. The largest non-Egegik component in 1993 was Ugashik River and in 1994 it was Kvichak River.

In Area C, Egegik River sockeye salmon comprised an estimated 81.9% of the catch in 1993 and 96.5% of the catch in 1994 (Table 3; Figure 9). Kvichak River sockeye salmon catches varied from 10.8% in 1993 to 2.9% in 1994. Naknek and Ugashik River sockeye salmon composed less than 5% and 3% respectively each year. Kvichak River had the largest non-Egegik component of this catch each year.

In Area D, Egegik River sockeye salmon catches varied from a high of 84.6% in 1993 to 40.0% in 1994 (Table 3; Figure 9). The percentages of Kvichak River sockeye salmon varied from 8.1% in 1993 to 47.4% in 1994. Some Naknek River sockeye salmon were found in 1993 (4.8%) and 1994 (10.7%). Ugashik River sockeye salmon composed less than 3% of the catch each year. The greatest non-Egegik component in 1993 was Kvichak River. While in 1994, Kvichak River catches in Area D (47.4%) were greater than the Egegik River catch (40.0%).

From 1993 to 1994 percent contribution of non-Egegik stocks increased in Area D and decreased in Areas A, B, and C (Figure 9). In general, contribution of non-Egegik sockeye salmon from 1993-1994 was greater in the northern portion of Middle Bluff area (Area D) than in the southern and central portions of the study area (Areas A, B, and C).

The results of the 1993-1994 Middle Bluff area stock identification testfishing studies only represent the findings from two years of data. In 1993, 9.3 million fish returned to the Kvichak River (below 1984-1993 average of 12.0 million), 4.7 million fish return to the Naknek River (similar to 1984-1993 average of 4.6 million), 23.3 million fish returned to the Egegik River (above 1984-1993 average of 10.9 million), and 5.7 million fish return to the Ugashik River (above 1984-1993 average of 4.7 million; ADF&G 1994). In 1994, 22.2 million fish returned to the Kvichak River (below 1985-1994 average of 11.9 million), 3.0 million fish return to the Naknek River (below 1985-1994 average of 4.6 million), 12.7 million fish returned to the Egegik River (above 1985-1994 average of 11.6 million), and 5.4 million fish return to the Ugashik River (above 1985-1994 average of 4.8 million; R.B. Russell, Alaska Department of Fish and Game, King Salmon, personal communication). Stock compositions that were found in the Middle Bluff study areas in 1993 and 1994 would probably differ from other years as the relative run sizes of the Kvichak, Naknek, Egegik, and Ugashik Rivers change.

CONCLUSIONS

Stock composition estimates varied considerably through time and among study areas, with no well defined trends. Results of the test fisheries indicated that stock mixing within the 1992 Naknek-Kvichak District study areas and the 1993-1994 Middle Bluff study areas were extremely complex, and did not identify specific boundary lines which would minimize the catch of other river stocks.

In the Naknek-Kvichak District study areas, the high variability of the percent composition of sockeye salmon catch by study area and stock suggest much stock intermingling within the Naknek Section and along the south boundary line (Loran C 9990-Y-32430). The stock compositions that were found in the Naknek-Kvichak District study areas in 1992 will probably change as the relative run sizes of the Kvichak and Naknek Rivers change.

In the Middle Bluff, two general conclusions can be drawn from these test fisheries: (1) in both years high percentages of Egegik River sockeye salmon were caught in these study areas and (2) at various times and places significant percentages of non-Egegik sockeye salmon, especially Kvichak River, were found throughout the study areas.

RECOMMENDATIONS

From the 1992 test fishing results, we gained some information on stock intermingling within the Naknek-Kvichak District study areas. However, since district catch stock identification studies will continue to provide stock composition estimates of Naknek-Kvichak District commercial catches, further Naknek-Kvichak District test fishery studies are not recommended because continued studies are not expected to further enhance our understanding of this phenomenon.

Test fish studies in the Middle Bluff area in 1993 and 1994 suggested that it may be desirable to continue this stock identification test fishery to better understand the spatial and temporal distribution of stocks within this area. In order to better address proposals to open the area for commercial fishing, additional years of stock composition estimates are needed.

LITERATURE CITED

Alaska Department of Fish and Game (ADF&G). 1993. Annual management report - 1992 - Bristol Bay Area. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A93-32, Anchorage.

Alaska Department of Fish and Game (ADF&G). 1994. Annual management report - 1993 - Bristol Bay Area. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report 2A94-02, Anchorage.

Burns, P.N. 1991. Separation of sockeye salmon stocks in east side Bristol Bay commercial harvests, 1983-1989. Master of Science Thesis. University of Alaska, Fairbanks.

Cook, R. and G. Lord. 1978. Identification of stocks of Bristol Bay sockeye salmon by evaluating scale patterns with a polynomial discriminant method. U.S. Fish and Wildlife Service, Fisheries Bulletin 76(2): 415-423.

Cross, B.A., and B.L. Stratton. 1989. Report to the Alaska Board of Fisheries on the stock composition of sockeye salmon catches made by a test fishery in the Egegik District of Bristol Bay in 1988. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2K89-2, Anchorage.

Cross, B.A., B.L. Stratton, and J.D. Miller. 1989a. Report to the Alaska Board of Fisheries on the stock composition of sockeye salmon catches within east side Bristol Bay fishing districts, 1986-1989. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Informational Report 2K89-21, Anchorage.

Cross, B.A., B.L. Stratton, and J.D. Miller. 1989b. Report to the Alaska Board of Fisheries on the stock composition of sockeye salmon catches made by test fisheries in the Egegik District of Bristol Bay in 1988-1989. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2K89-21, Anchorage.

Eggers, D.M., and D.E. Rogers. 1987. The cycle of runs of sockeye salmon (*Oncorhynchus nerka*) to the Kvichak River, Bristol Bay, Alaska: cyclic dominance or depensatory fishing? Pages 343-366 *in* H.D. Smith, L. Margolis, and C.C. Wood, editors. Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Canadian Special Publication of Fisheries and Aquatic Sciences 96, Ottawa.

LITERATURE CITED (Continued)

Fisher, R. 1936. The use of multiple measurements in taxonomic problems. Annual Eugenics 7:179-188.

Fried, S.M., and H.J. Yuen. 1985. Stock composition of sockeye salmon catches sampled within east side Bristol Bay fishing districts: a preliminary study using scale pattern characteristics to identify stocks. Alaska Department of Fish and Game, Division of Commercial Fisheries, Bristol Bay Area Data Report 85-14, Anchorage.

Koo, T.S.Y. 1962. Age designation in salmon. Pages 37-48 in T.S.Y. Koo, editor. Studies of Alaska red salmon. University of Washington Publications in Fisheries, New Series, Volume I, Seattle, Washington.

Minard, R.E., and C.P. Meacham. 1987. Sockeye salmon (*Oncorhynchus nerka*) management in Bristol Bay, Alaska. Pages 336-342 *in* H.D. Smith, L. Margolis, and C.C. Wood, editors. Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Canadian Special Publication of Fisheries and Aquatic Sciences 96, Ottawa.

Miller, J.D., B.A. Cross, and B.L. Stratton. 1991a. Stock composition of sockeye salmon catches made by a test fishery in Egegik District of Bristol Bay in 1990. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2K91-02, Anchorage.

Miller, J.D., B.A. Cross, and B.L. Stratton. 1991b. Report to the Alaska Board of Fisheries on the stock composition of sockeye salmon catches made by a test fishery in Egegik District of Bristol Bay, 1988-1991. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A91-14, Anchorage.

Mosher, K. 1968. Photographic atlas of sockeye salmon scales. U.S. Fish and Wildlife Service, Fishery Bulletin 67:243-280.

Pella, J., and T. Robertson. 1979. Assessment of composition of stock mixtures. Fishery Bulletin 77(2):387-398.

Pennoyer, S., and M. Nelson. 1967. Summary of Bristol Bay tagging studies 1950-1966. Alaska Department of Fish and Game, Division of Commercial Fisheries, Bristol Bay Area Data Report 13, Anchorage.

LITERATURE CITED (Continued)

Stratton, B.L., J.D. Miller, and B.A. Cross. 1991. Report to the Alaska Board of Fisheries on the stock composition of sockeye salmon catches within east side Bristol Bay fishing districts, 1983-1991. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A91-14, Anchorage.

Stratton, B.L., and J.D. Miller. 1994. Origins of sockeye salmon catches within east side Bristol Bay fishing districts, 1992. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Technical Fishery Report 94-10, Juneau.

Straty, R.R. 1975. Migratory routes of adult sockeye salmon, *Oncorhynchus nerka*, in the Eastern Bering Sea and Bristol Bay. NOAA Technical Report NMFS SSRF-690. Seattle.

Table 1. Locations of stock identification test fishery study areas, Naknek-Kvichak District, 1992, and Middle Bluff area, 1993-1994.

Location	Study Area Name	Boundary	LORAN C Coordinates
Naknek-Kvichak District	A	North	9990-Y-32350
		South	9990-Y-32360
		East	Shoreline
		West	9990-Z-44980
	B	North	9990-Y-32365
		South	9990-Y-32375
		East	Shoreline
		West	9990-Z-44990
	C	North	9990-Y-32395
		South	9990-Y-32410
		East	9990-Z-45025
		West	9990-Z-45040
	D	North	9990-Y-32390
		South	Shoreline
		East	9990-Z-45000
		West	9990-Z-45015
	E	North	9990-Y-32420
		South	9990-Y-32430
		East	9990-Z-45090
		West	9990-Z-45110
	F	North	9990-Y-32420
		South	9990-Y-32430
		East	9990-Z-45060
		West	9990-Z-45075
	G	North	9990-Y-32420
		South	9990-Y-32430
		East	9990-Z-45030
		West	9990-Z-45050

-Continued-

Table 1. (p 2 of 2).

Location	Study Area Name	Boundary	LORAN C Coordinates
Middle Bluff Area	A	North	9990-Y-32555
		South	9990-Y-32565
		East	Shoreline
		West	9990-Z-45135
	B	North	9990-Y-32540
		South	9990-Y-32550
		East	Shoreline
		West	9990-Z-45135
	C	North	9990-Y-32525
		South	9990-Y-32535
		East	Shoreline
		West	9990-Z-45135
	D	North	9990-Y-32510
		South	9990-Y-32520
		East	Shoreline
		West	9990-Z-45130

Table 2. Stock composition of sockeye salmon by study area, Naknek-Kvichak District stock identification test fishery, 1992.

Study Area	Mean Percent Abundance By Stock			
	Kvichak-Ugashik	Naknek	Egegik	Total
A	51.4	38.6	10.0	100.0
B	68.6	31.3	0.1	100.0
C	54.5	41.8	3.7	100.0
D	31.2	68.8	0.0	100.0
E	23.9	76.1	0.0	100.0
F	63.9	28.5	7.6	100.0
G	67.3	23.1	9.6	100.0

Table 3. Stock composition of sockeye salmon by study area and year, Middle Bluff area stock identification test fishery, 1993-1994.

Study Area	Year	Mean Percent Abundance Stock				Total
		Kvichak	Naknek	Egegik	Ugashik	
A	1993	14.2	6.6	77.5	1.7	100.0
	1994	3.5	0.7	95.8	0.0	100.0
B	1993	10.1	5.8	64.3	19.8	100.0
	1994	21.7	4.7	73.6	0.0	100.0
C	1993	10.8	4.4	81.9	2.9	100.0
	1994	2.9	0.6	96.5	0.0	100.0
D	1993	8.1	4.8	84.6	2.6	100.0
	1994	47.4	10.7	40.0	1.9	100.0

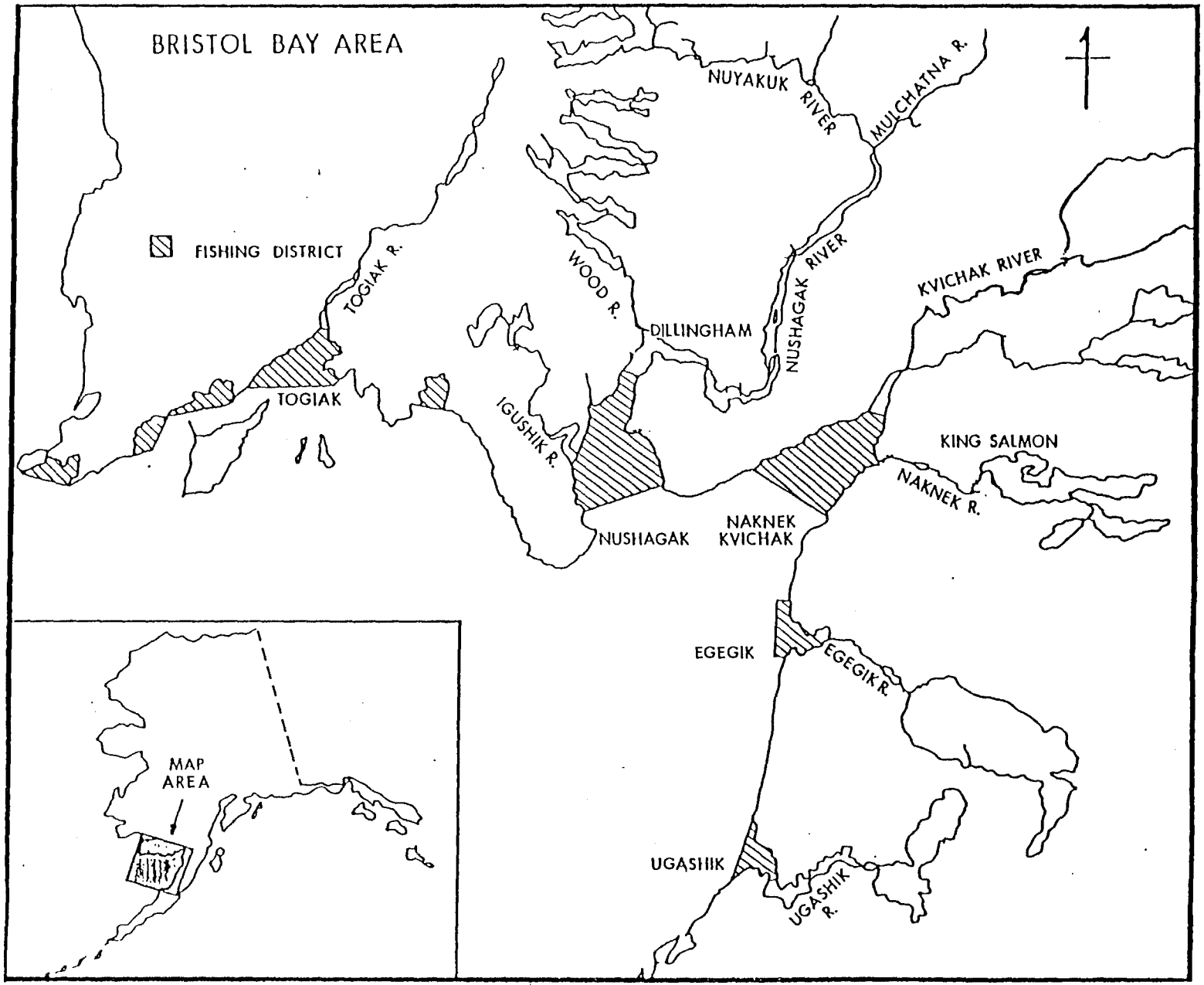

Figure 1. Bristol Bay Area commercial salmon fishing districts and major rivers.

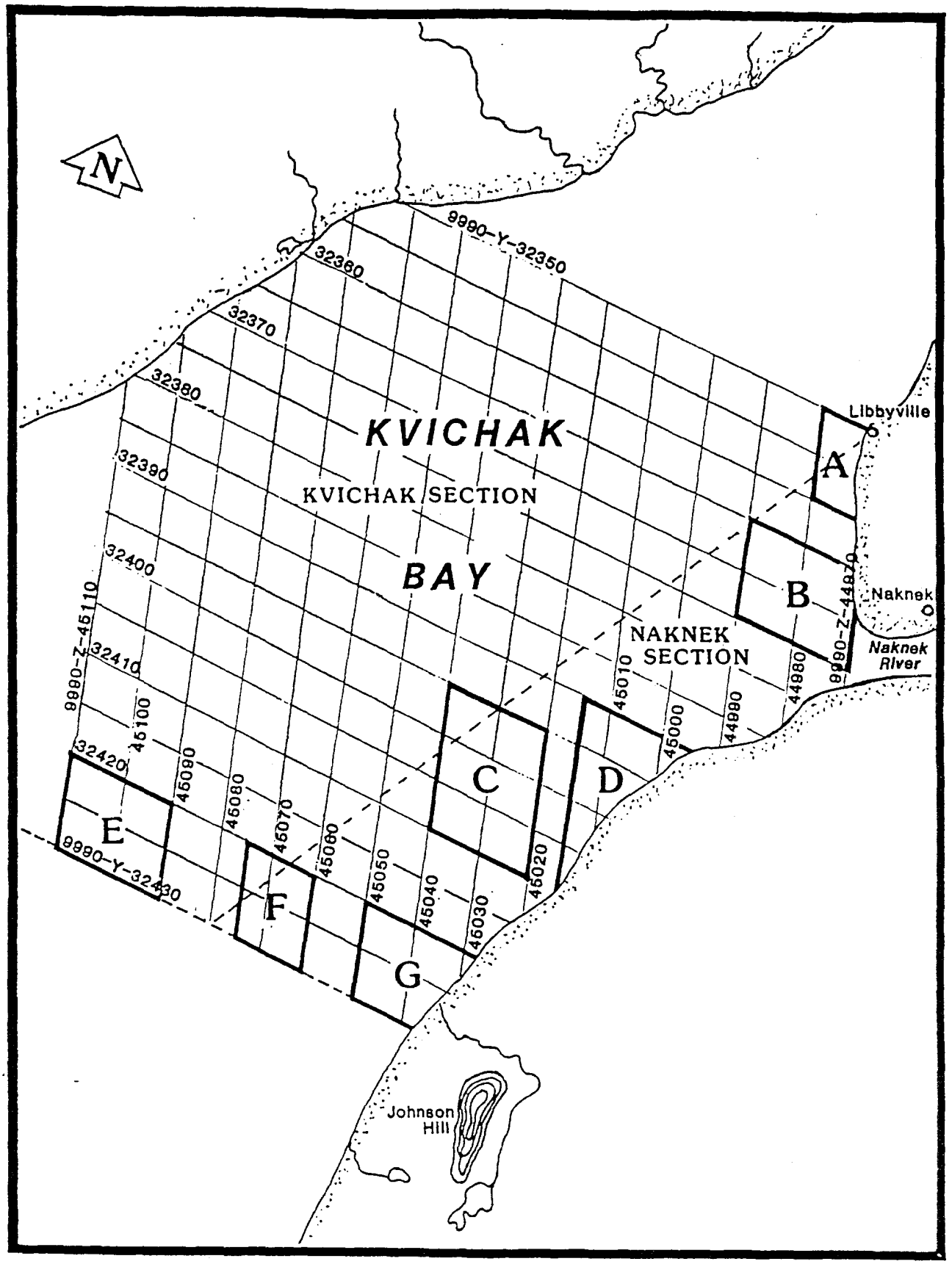

Figure 2. Locations of test fishery study areas in Naknek-Kvichak District, 1992.

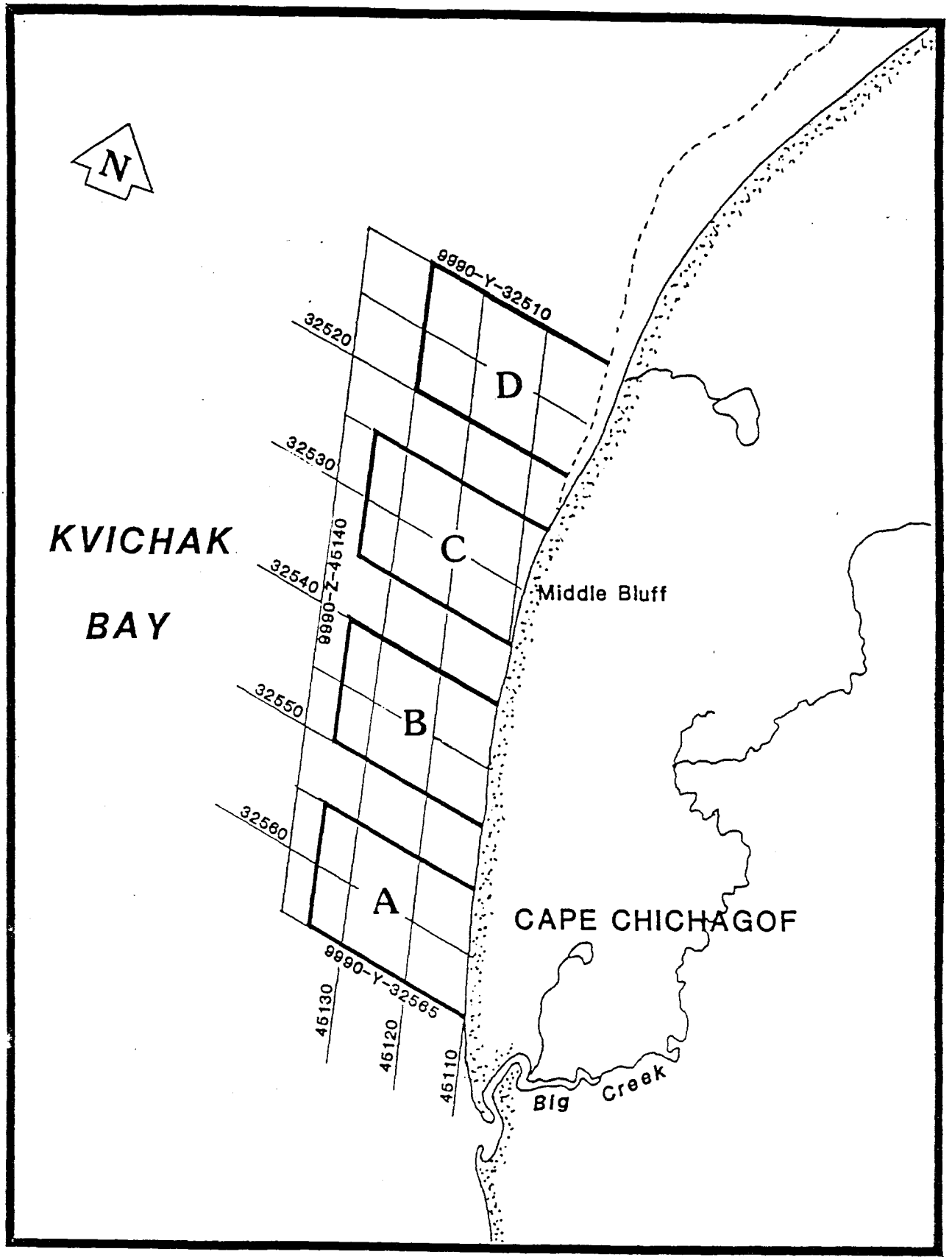

Figure 3. Locations of test fishery study areas in Middle Bluff area, 1993-1994.

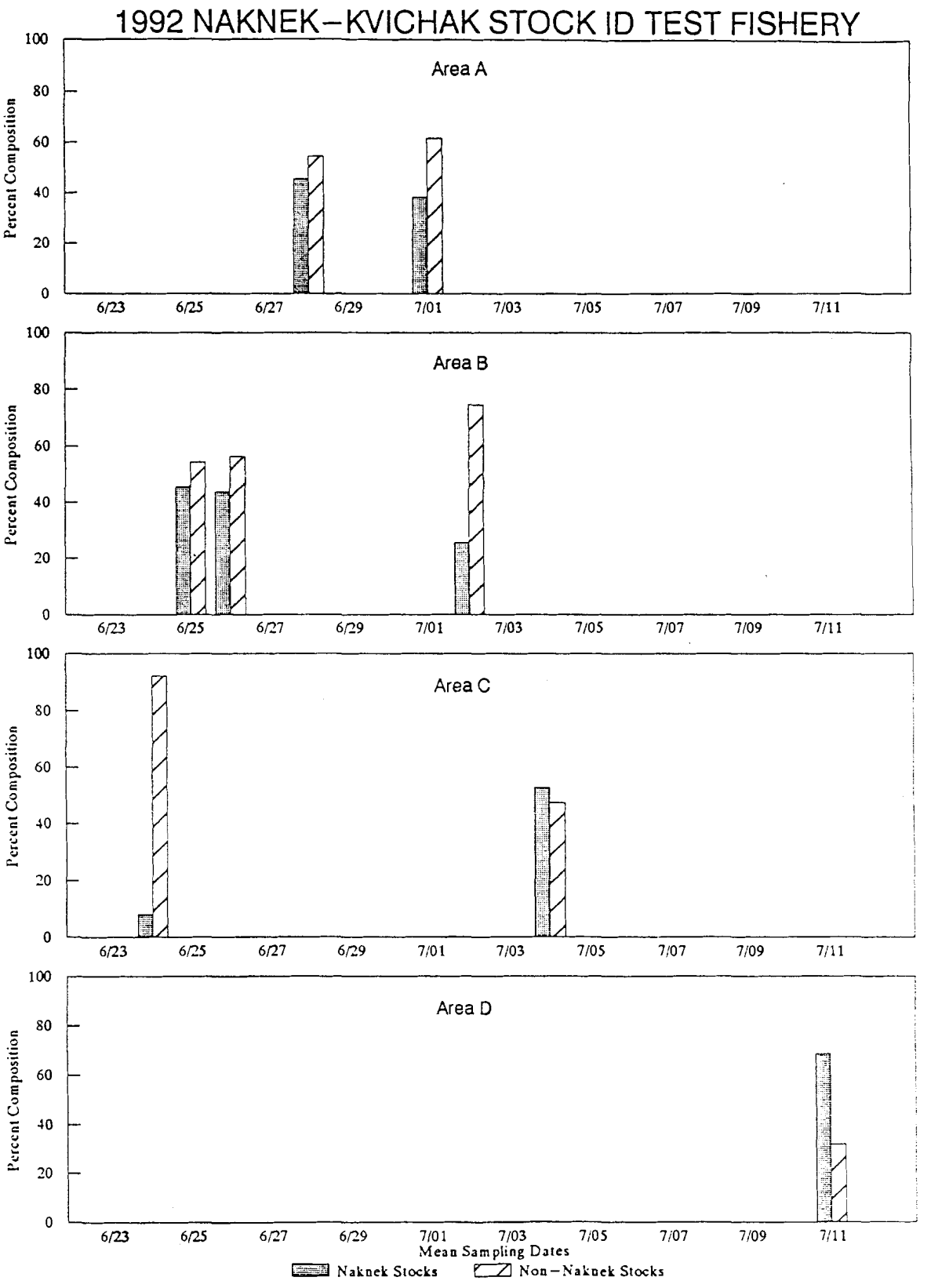

Figure 4. Percent composition of Naknek versus non-Naknek River sockeye salmon catches by mean sampling dates, study areas A-D, Naknek-Kvichak District stock identification test fishery, 1992.

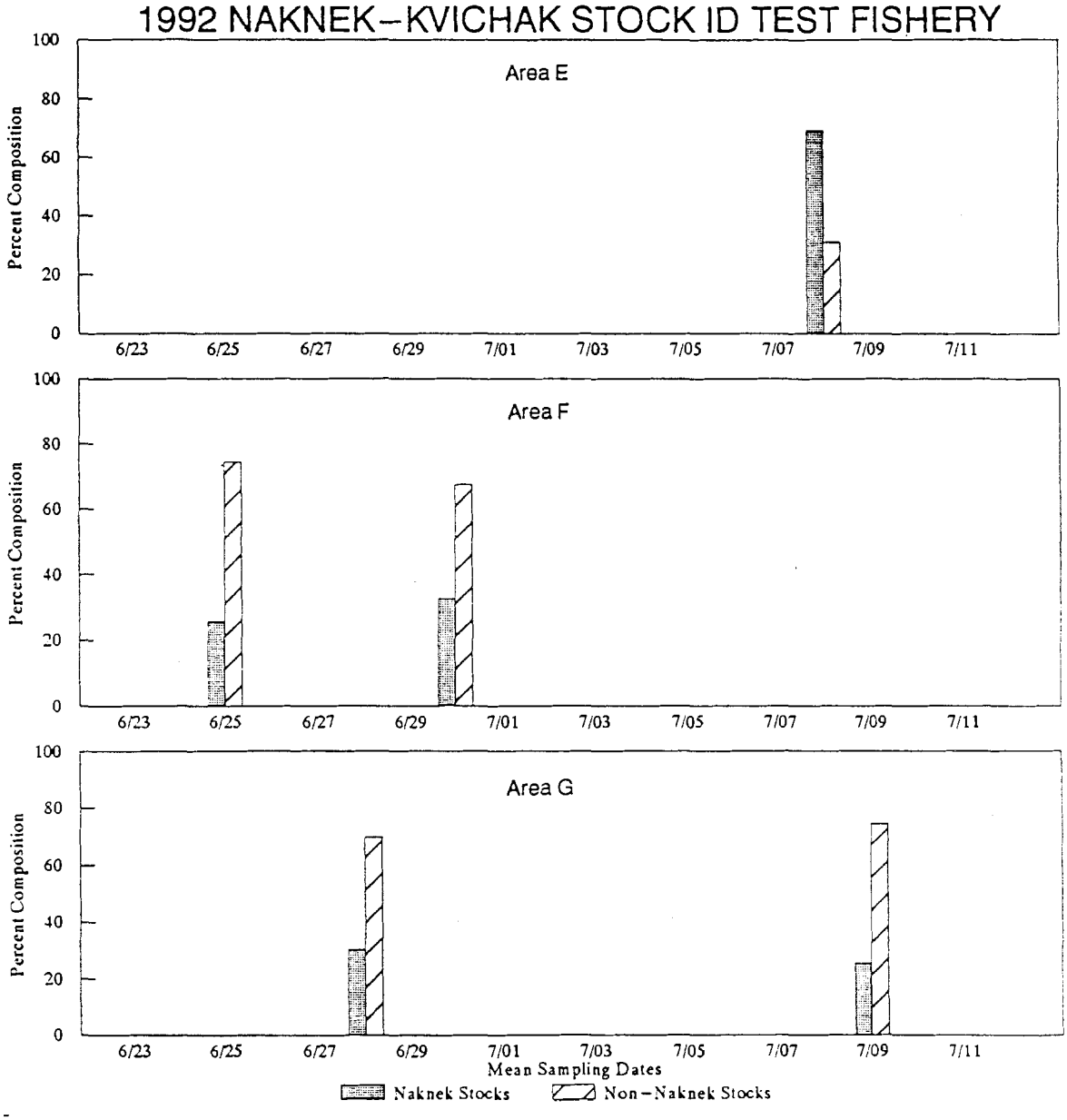

Figure 5. Percent composition of Naknek versus non-Naknek River sockeye salmon catches by mean sampling dates, study areas E-G, Naknek-Kvichak District stock identification test fishery, 1992.

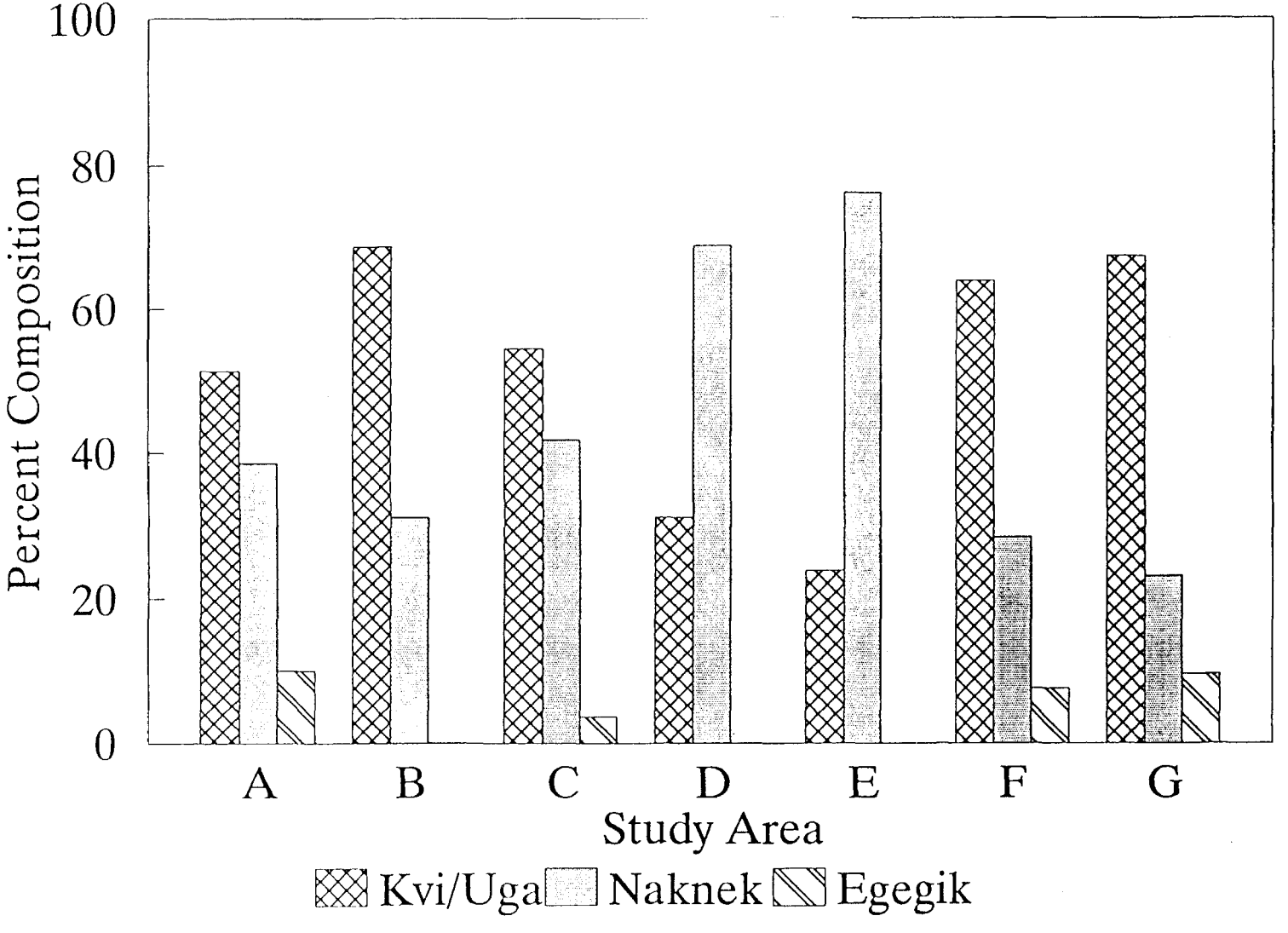

Figure 6 Percent composition of sockeye salmon catch by study area and stock, Naknek-Kvichak District stock identification test fishery, 1992.

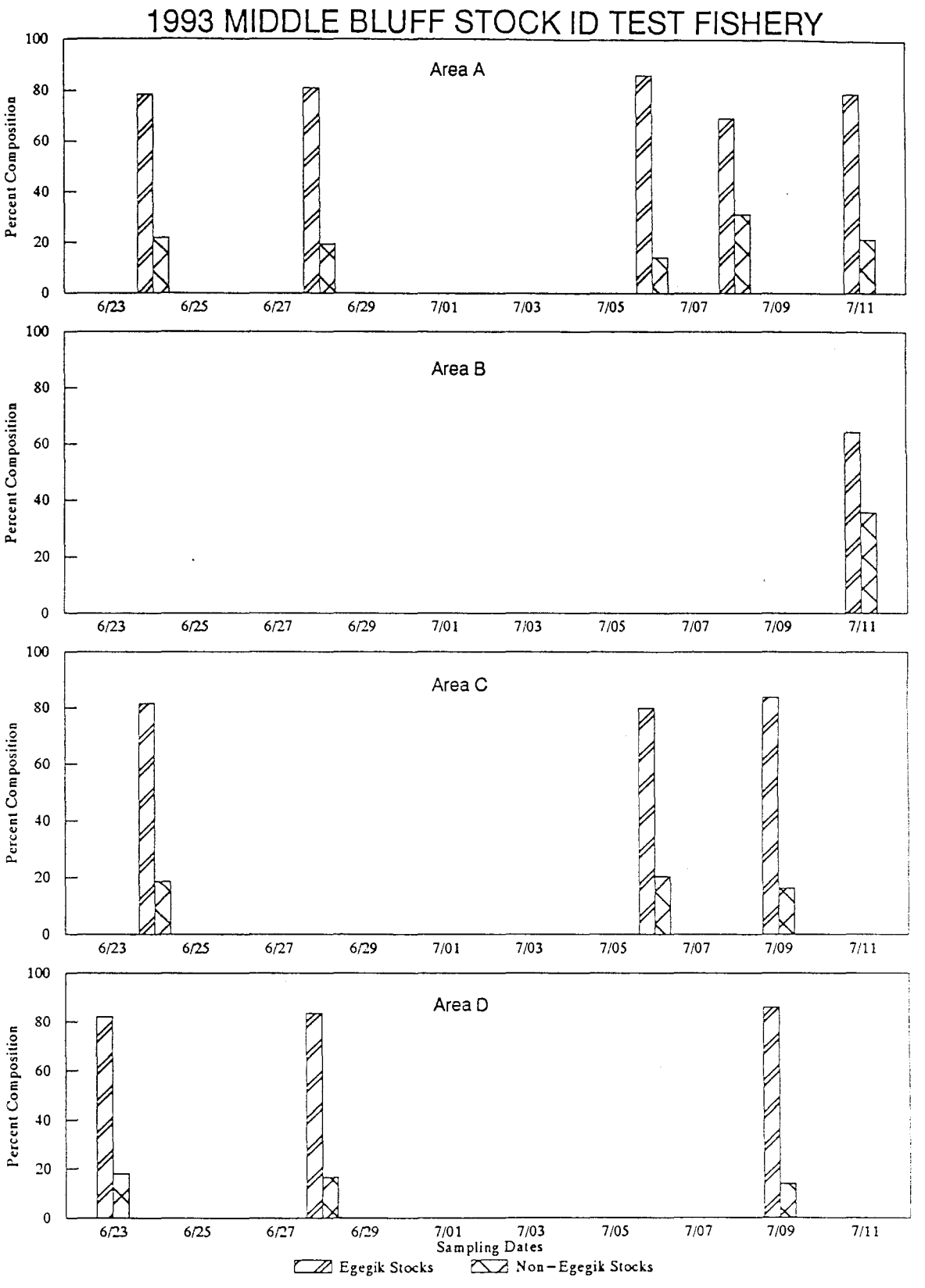

Figure 7. Percent composition of Egegik versus non-Egegik River sockeye salmon catches by mean sampling dates, study areas A-D, Middle Bluff area stock identification test fishery, 1993.

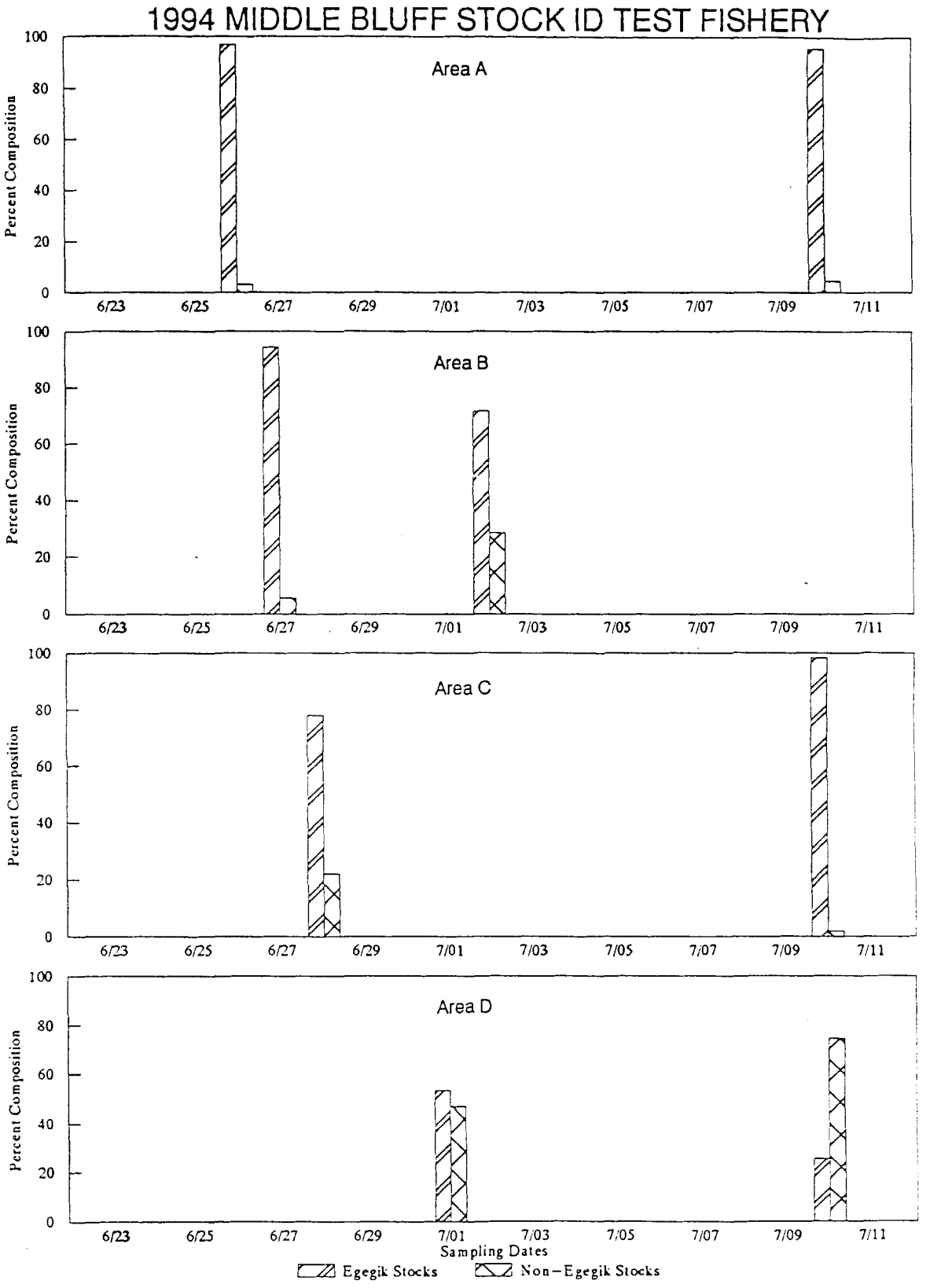

Figure 8. Percent composition of Egegik versus non-Egegik River sockeye salmon catches by mean sampling dates, study areas A-D, Middle Bluff area stock identification test fishery, 1994.

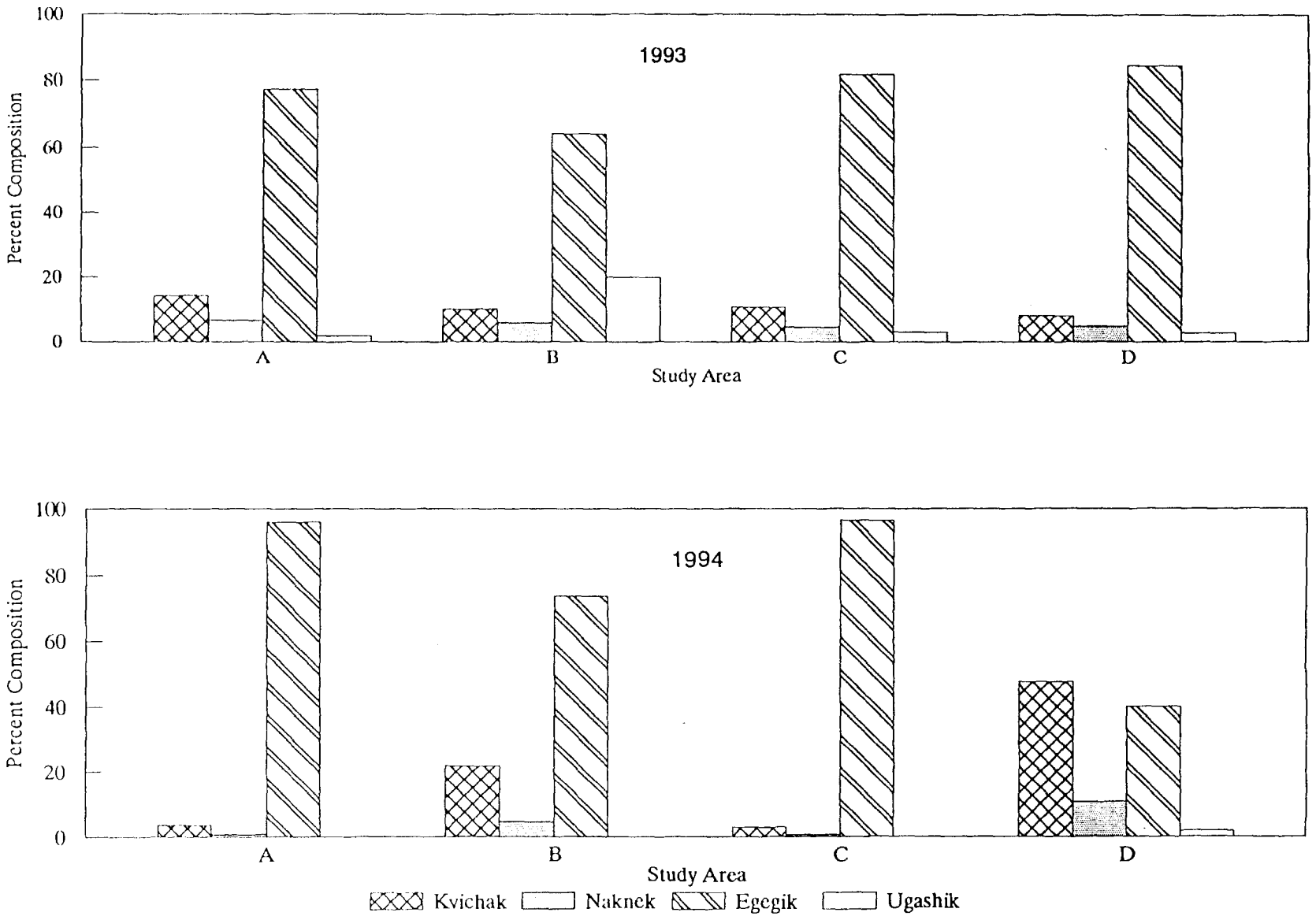

Figure 9. Percent composition of sockeye salmon catch by study area and stock, Middle Bluff area stock identification test fishery, 1993-1994.

APPENDIX A

Methods Used to Estimate Mean Fishing Time and Daily Abundance Indices

Daily abundance indices by study area and date were calculated using mean fishing time (MT) and catch per unit effort (CPUE) from each drift.

Mean fishing time, in minutes, was calculated for each drift as:

$$MT = SI - FO + \{[(FO - SO) + (FI - SI)]/2\}$$

where:

SO = time gill net first entered the water;

FO = time gill net fully deployed;

SI = time gill net retrieval began; and

FI = time gill net retrieval complete.

The daily test fishing index for each study area was calculated as the mean of individual CPUE values obtained from drifts made the same day:

$$I_i = \frac{\sum_{j=1}^{n} C_j}{n}$$

where:

I_i = daily test fishing index (abundance index) for day i;

n = number of drifts made during day i; and

C_j = CPUE value (sockeye salmon caught per 100 fathom hrs) for drift j:

$$C_j = 6000\ [N_j / (G\ MT_j)]$$

where:

N_j = number of sockeye salmon caught in drift j;

G = gill net length in fathoms; and

MT_j = mean fishing time for drift j.

APPENDIX B

Stock Identification Variables

Appendix B.1. Scale variables screened for linear discriminant function analysis of sockeye salmon stock identification fisheries, Naknek-Kvichak District, 1992 and Middle Bluff area, 1993-1994.

Variable Number	Variable Name	Zone
		First Freshwater Annular Zone
1	NC1FW	Number of circuli first freshwater
2	S1FW	Size (width) of first freshwater
3 (16)	CO-C2	Distance, scale focus (CO) to circulus 2 (C2)
4 (17)	CO-C4	Distance, scale focus to circulus 4
5 (18)	CO-C6	Distance, scale focus to circulus 6
6 (19)	CO-C8	Distance, scale focus to circulus 8
7 (20)	C2-C4	Distance, circulus 2 to circulus 4
8 (21)	C2-C6	Distance, circulus 2 to circulus 6
9 (22)	C2-C8	Distance, circulus 2 to circulus 8
10 (23)	C4-C6	Distance, circulus 4 to circulus 6
11 (24)	C4-C8	Distance, circulus 4 to circulus 8
12 (25)	C(NC-4)-E1FW	Distance, circulus (number circuli first freshwater minus 2) to end first freshwater
13 (26)	C(NC-2)-E1FW	Distance, circulus (number circuli first freshwater minus 4) to end first freshwater
14	C2-E1FW	Distance, circulus 2 to end first freshwater
15	C4-E1FW	Distance, circulus 4 to end first freshwater
16 thru	CO-C2/S1FW ...	Relative widths, (variables 3-13)/S1FW
26	C(NC-2)-E1FW/S1FW	
27	S1FW/NC1FW	Average interval between circuli in first freshwater
28	NC 1ST 3/4	Number of circuli in first 3/4 of first freshwater
29	MAX DIST	Maximum distance between 2 consecutive circuli in first freshwater
30	MAX DIST/S1FW	Relative width, (variable 29)/S1FW
		Second Freshwater Annular Zone
31	NC2FW	Number of circuli second freshwater
32	S2FW	Size (width) of second freshwater
33 (46)	E1FW-C2	Distance, end of first freshwater to circulus 2 (C2) in second freshwater
34 (47)	E1FW-C4	Distance, end of first freshwater to circulus 4
35 (48)	E1FW-C6	Distance, end of first freshwater to circulus 6
36 (49)	E1FW-C8	Distance, end of first freshwater to circulus 8
37 (50)	C2-C4	Distance, circulus 2 to circulus 4
38 (51)	C2-C6	Distance, circulus 2 to circulus 6
39 (52)	C2-C8	Distance, circulus 2 to circulus 8
40 (53)	C4-C6	Distance, circulus 4 to circulus 6
41 (54)	C4-C8	Distance, circulus 4 to circulus 8
42 (55)	C(NC-4)-E2FW	Distance, circulus (number circuli second freshwater minus 4) to end second freshwater
43 (56)	C(NC-2)-E2FW	Distance, circulus (number circuli second freshwater minus 2) to end second freshwater
44	C2-E2FW	Distance, circulus 2 to end second freshwater
45	C4-E2FW	Distance, circulus 4 to end second freshwater
46 thru	E1FW-C2/S2FW ...	Relative widths, (variables 33-43)/S2FW
56	C(NC-2)-E2FW/S2FW	
57	S2FW/NC2FW	Average interval between circuli in second freshwater
58	NC 1ST 3/4	Number of circuli in first 3/4 of second freshwater
59	MAX DIST	Maximum distance between 2 consecutive circuli in second freshwater
60	MAX DIST/S2FW	Relative width, (variable 59)/S2FW

-Continued-

Appendix B.1. (p 2 of 2).

Variable Number	Variable Name	Zone
		Plus Growth Zone
61	NCPG	Number of circuli in plus growth
62	SPGZ	Size (width) plus growth zone
		Freshwater and Plus Growth Zones
63	NC1FW + NC2FW	Total number of circuli first and second freshwater
64	S1FW + S2FW	Total size (width) of first and second freshwater
65	NC1FW+NC2FW+NCPG	Total number of circuli first and second freshwater and plus growth
66	S1FW+S2FW+SPGZ	Total size (width) first and second freshwater and plus growth
67	S1FW/S1FW+S2FW+SPGZ	Relative width, (variable 2)/S1FW+S2FW+SPGZ
68	SPGZ/S1FW+S2FW+SPGZ	Relative width, (variable 62)/S1FW+S2FW+SPGZ
69	S2FW/S1FW+S2FW+SPGZ	Relative width, (variable 32)/S1FW+S2FW+SPGZ
		First Marine Annular Zone
70	NC1OZ	Number of circuli in first ocean zone
71	S1OZ	Size (width) first ocean zone
72 (90)	EFW-C3	Distance, end of freshwater growth to circulus 3
73 (91)	EFW-C6	Distance, end of freshwater growth to circulus 6
74 (92)	EFW-C9	Distance, end of freshwater growth to circulus 9
75 (93)	EFW-C12	Distance, end of freshwater growth to circulus 12
76 (94)	EFW-C15	Distance, end of freshwater growth to circulus 15
77 (95)	C3-C6	Distance, circulus 3 to circulus 6
78 (96)	C3-C9	Distance, circulus 3 to circulus 9
79 (97)	C3-C12	Distance, circulus 3 to circulus 12
80 (98)	C3-C15	Distance, circulus 3 to circulus 15
81 (99)	C6-C9	Distance, circulus 6 to circulus 9
82 (100)	C6-C12	Distance, circulus 6 to circulus 12
83 (101)	C6-C15	Distance, circulus 6 to circulus 15
84 (102)	C9-C15	Distance, circulus 9 to circulus 15
85 (103)	C(NC-6)-E1OZ	Distance, circulus (number circuli first ocean minus 6) to end first ocean
86 (104)	C(NC-3)-E1OZ	Distance, circulus (number circuli first ocean minus 3) to end first ocean
87	C3-E1OZ	Distance, circulus 3 to end of first ocean
88	C9-E1OZ	Distance, circulus 9 to end of first ocean
89	C15-E1OZ	Distance, circulus 15 to end of first ocean
90 thru 104	EFW-C3/S1OZ ... C(NC-3)-E1OZ/S1OZ	Relative widths, (variables 72-86)/S1OZ
105	S1OZ/NC1OZ	Average interval between circuli in first ocean
106	NC 1ST 1/2	Number of circuli in first 1/2 of first ocean
107	MAX DIST	Maximum distance between 2 consecutive circuli in first ocean
108	MAX DIST/S1OZ	Relative width, (variable 107)/S1OZ
		Second Marine Annular Zone
109	S2OZ	Size (width) of second ocean zone

APPENDIX C

Method Used to Calculate Mean Percent Abundance by Stock

Percent of sockeye salmon by stock caught in a given study area was weighted by the daily abundance index for that area:

$$MA_{mk} = \frac{\sum_{i=1}^{n} (a_{mki} b_{mi})}{\sum_{i=1}^{n} (b_{mi})}$$

where:

MA_{mk} = mean percent abundance in area *m* of stock *k*;

a_{mki} = percent interception in area *m* of stock *k* on date *i*;

b_{mi} = abundance index in area *m* on date *i*; and

n = number of sample dates.

APPENDIX D

Test Fish Data

Appendix D.1. Location, time, tide stage, and sockeye salmon catch for all analyzed gill net drifts, Naknek-Kvichak District stock identification test fishery, 1992.

Date	Time [a] High Tide	Time [a] Low Tide	Sample Area	Drift #	Time Fished	LORAN C Coordinates [b] Net In	LORAN C Coordinates [b] Net Out	Length (fathoms)	Mean Fishing Time (min)	Sockeye Salmon Catch	Index (CPUE)	Wind Direction	Wind Velocity (knots)
6/21	0823	0235	B	1	1006 - 1245	32368 and 44974	32571 and 44982	150	144.0	63	17.5	SW	10
	2040	1544		2	1301 - 1356	32371 and 44985	32573 and 44990	150	46.5	17	14.6	SSW	0 - 05
				3	1001 - 1150	32370 and 44972	32372 and 44984	150	103.0	57	22.1	SW	10 -15
				4	1020 - 1325	32367 and 44975	32373 and 44992	150	178.0	127	28.5	S	15
			C	1	1436 - 1645	32398 and 45030	32408 and 45028	150	116.5	48	21.6	SSW	0 - 05
				2	1709 - 1732	32408 and 45028	32406 and 45025	150	16.5	2	4.8	SSW	0 - 05
				3	1745 - 1848	32400 and 45027	32395 and 45026	150	49.0	81	66.1	SSW	0 - 05
				4	1436 - 1645	32401 and 45033	32399 and 45025	150	42.0	5	4.8		0
				5	1433 - 1643	32396 and 45027	32395 and 45025	150	125.0	31	9.9	SW	10
				6	1440 - 1551	32399 and 45027	32398 and 45026	150	64.5	6	3.7	S	05
				7	1635 - 1752	32407 and 45037	32396 and 45019	150	70.0	89	50.9	S	05
				8	1836 - 1944	32398 and 45033	32394 and 45024	150	63.5	3	1.9	S	05
6/24	1002	0502	B	5	0934 - 1106	32373 and 44988	32374 and 44988	150	84.5	6	2.8	SW	05
	2318	1739		6	1284 - 1402	32366 and 44973	32374 and 44989	150	144.5	15	4.2	SW	05 - 10
				7	0929 - 1223	32372 and 44982	32375 and 44991	150	168.5	6	1.4	S	05
				8	1246 - 1342	32370 and 44975	32371 and 44975	150	51.0	11	8.6	S	10
				9	1359 - 1526	32368 and 44986	32373 and 44991	150	79.0	66	33.4	S	10
				10	0924 - 1024	32371 and 44987	32370 and 44981	150	54.0	1	0.7	SW	05
			C	9	1430 - 1620	32397 and 45025	32405 and 45038	150	102.0	6	204.0	SW	05 - 10
				10	2005 - 2225	32409 and 45037	32400 and 45025	150	125.0	175	56.0	SW	05
				11	2135 - 2250	32402 and 45033	32395 and 45026	150	67.0	84	50.1	SW	05
				12	1555 - 1809	32397 and 45024	32395 and 45021	150	126.0	15	4.8	S	10
				13	1831 - 1944	32405 and 45038	32394 and 45017	150	66.5	239	143.8	S	10
				14	2011 - 2141	32405 and 45034	32395 and 45013	150	83.5	185	88.6	S	05
				15	2158 - 2304	32398 and 45030	32391 and 45017	150	57.0	34	35.8	S	05
				16	1421 - 1655	32398 and 45021	32406 and 45037	150	148.5	8	2.2	SW	10
				17	2003 - 2023	32411 and 45021	32410 and 45020	100	16.0	0	0.0	S	05
				18	2043 - 2211	32409 and 45038	32399 and 45022	150	82.5	79	38.3	S	05
			F	1	1644 - 1830	32420 and 45066	32419 and 45068	150	102.0	1	0.4	SW	05 - 10
				2	1855 - 1955	32429 and 45066	32416 and 45052	150	50.0	45	36.0	SW	05 - 10
				3	1742 - 1943	32430 and 45060	32408 and 45033	150	114.0	202	70.9	S	05

-Continued-

Date	Time [a] High Tide	Time [a] Low Tide	Sample Area	Drift #	Time Fished	LORAN C Coordinates [b] Net In	LORAN C Coordinates [b] Net Out	Length (fathoms)	Mean Fishing Time (min)	Sockeye Salmon Catch	Index (CPUE)	Wind Direction	Wind Velocity (knots)
6/25	1038	0555	C	19	0119 - 0228	32395 and 45025	32401 and 45034	150	63.5	18	11.3	E	25 - 30
	-	1818		20	0246 - 0537	32405 and 45029	32424 and 45067	150	104.0	186	45.4	E	40
				21	1329 - 1544	32399 and 45020	32420 and 45061	150	137.0	55	16.1	E	35
			G	1	0615 - 0804	32425 and 45050	32405 and 45034	150	102.5	127	49.6	E	40 - 50
				2	1629 - 1804	32420 and 45048	32425 and 45060	150	88.0	64	29.1	E	40
				3	1838 - 2015	32427 and 45053	32406 and 45040	150	89.5	117	52.3	E	35
6/26	0010	0649	B	1	1250 - 1425	32369 and 44973	32370 and 44982	150	71.0	550	309.9	NE	05
	2316	1859		2	1237 - 1338	32369 and 44974	32372 and 44983	150	52.5	494	376.4	SE	05 - 15
				3	1405 - 1458	32370 and 44978	32371 and 44984	100	47.0	41	52.3	SE	15
				4	1249 - 1410	32367 and 44978	32370 and 44982	150	74.5	159	85.4	E	15
				5	1425 - 1521	32375 and 44987	32371 and 44981	50	50.0	120	288.0	E	10
			F	4	1857 - 2015	32429 and 45062	32420 and 45061	150	70.0	33	18.9	ESE	15 - 20
				5	2047 - 2132	32429 and 45062	32420 and 45061	150	29.0	115	158.6	ESE	15 - 20
				6	1950 - 2131	32430 and 45060	32418 and 45059	150	90.0	358	159.1	SE	20
			G	4	1946 - 2107	32430 and 45048	32417 and 45038	150	74.5	48	25.8	SE	15 - 20
6/28	0151	0838	A	1	0515 - 0558	32350 and 44973	32355 and 44977	150	36.0	30	33.3	N	08
	1244	2028		2	0607 - 0653	32350 and 44973	32356 and 44977	150	37.0	48	51.9	N	08
				3	0657 - 0759	32353 and 44975	32357 and 44978	150	435.0	109	100.2	N	08
			F	1	0905 - 1023	32429 and 45069	32416 and 45063	150	68.5	27	15.8	NE	10
				2	0843 - 0923	32430 and 45064	32428 and 45061	150	40.0	12	12.0	E	5
				3	0930 - 1042	32430 and 45069	32416 and 45059	150	33.5	27	32.2	E	05 - 10
				4	0908 - 1034	32440 and 45061	32416 and 45050	150	81.0	27	13.3	N	08

-Continued-

Appendix D.1. (p 3 of 4)

Date	Time [a] High Tide	Time [a] Low Tide	Sample Area	Drift #	Time Fished	LORAN C Coordinates [b] Net In	LORAN C Coordinates [b] Net Out	Length (fathoms)	Mean Fishing Time (min)	Sockeye Salmon Catch	Index (CPUE)	Wind Direction	Wind Velocity (knots)
7/01	0420	1119	A	1	1826 - 2204	32351 and 44973	32353 and 44974	100	178.5	569	191.3	WSW	0 - 05
	1532	2300		2	0430 - 0504	32351 and 44975	32351 and 44978	150	29.0	3	4.1	-	-
				3	0509 - 0554	32351 and 44973	32357 and 44978	150	39.0	4	4.1	-	-
			B	1	1927 - 2032	32367 and 44984	32376 and 45003	150	39.0	474	486.2	-	-
				2	2159 - 2330	32362 and 44978	32373 and 44975	150	67.0	1000	597.0	-	-
			C	1	1541 - 1617	32407 and 45027	-	150	31.0	98	126.5	-	-
			F	5	1139 - 1155	32430 and 45069	32428 and 45066	100	13.0	9	41.5	N	0 - 05
				6	1158 - 1223	32429 and 45068	32425 and 45081	100	21.5	2	5.6	N	0 - 05
				7	1225 - 1250	32422 and 45064	32422 and 45056	100	19.5	92	283.1	N	0 - 05
				8	1252 - 1317	32422 and 45056	32417 and 45051	100	15.5	72	278.7		0
				9	1318 - 1427	32431 and 45054	32407 and 45042	100	61.0	67	65.9		0
				10	0938 - 1004	32428 and 45062	32430 and 45068	150	21.0	2	3.8	-	-
				11	1110 - 1218	32429 and 45069	32420 and 45058	150	56.0	176	125.7	-	-
				12	1226 - 1255	32425 and 45064	32422 and 45062	150	29.5	85	115.3	-	-
				13	1314 - 1334	32430 and 45071	32425 and 45065	150	15.5	4	10.3	-	-
				14	1306 - 1401	32429 and 45066	32421 and 45055	150	48.5	86	70.9	NW	0 - 03
				15	1421 - 1556	32425 and 45072	32423 and 45062	150	87.0	3	1.4	NW	0 - 05
			G	5	1449 - 1605	32430 and 45035	32434 and 45039	100	68.5	66	57.8		0
7/02	0508	1212	B	3	0652 - 0910	32365 and 44975	32374 and 44994	150	113.0	624	220.9	SW	05 -10
	1637	2356		4	0933 - 1011	32365 and 44982	32371 and 44992	150	33.5	152	181.5	SE	10
			G	6	1326 - 1420	32429 and 45052	32418 and 45040	150	45.0	388	344.9	S	10
				7	1501 - 1646	32430 and 45048	32424 and 45044	150	83.5	903	432.6	S	10
7/08	1003	0456	E	1	0727 - 0853	32430 and 45104	32406 and 45080	150	70.0	317	181.1	NE	05 - 10
	2322	1728		2	0927 - 1024	32428 and 45109	32433 and 45112	150	45.5	130	114.3	NE	0 - 05
				3	1040 - 1133	32429 and 45106	32438 and 45119	150	39.5	308	311.9	ENE	0 - 05
				4	1225 - 1250	32419 and 45090	32428 and 45096	150	20.0	7	14.0	ENE	0 - 05

-Continued-

Appendix D.1. (p 4 of 4)

Date	Time [a] High Tide	Time [a] Low Tide	Sample Area	Drift #	Time Fished	LORAN C Coordinates [b] Net In	LORAN C Coordinates [b] Net Out	Length (fathoms)	Mean Fishing Time (min)	Sockeye Salmon Catch	Index (CPUE)	Wind Direction	Wind Velocity (knots)
7/09	1055 -	0558 1820	C	2	0535 - 0726	32398 and 45018	32393 and 43025	150	96.5	251	104.0	ESE	10 - 20
			D	1	1856 - 2043	32393 and 45017	32395 and 45009	150	88.0	477	216.8	SW	0 - 05
			G	1	2357 - 0148	32428 and 45043	32433 and 45059	150	92.5	253	109.4	ESE	10 - 20
				2	0243 - 0410	32416 and 45042	32433 and 45069	150	65.5	309	188.7	ESE	10 - 20
7/12	0220	0859	D	2	0121 - 0209	32394 and 45010	32391 and 45007	150	36.0	114	126.7	S	15
	1331	2053		3	0232 - 0401	32383 and 44987	32386 and 45001	150	75.0	168	89.6	S	10

[a] Tide times are presented in military time (24 h clock) and were determined by using Nushagak District tide tables and the Naknek River Entrance correction factors (e.g., high -0019, low +0026).

[b] LORAN C coordinates in the 32000 range are preceded by 9990-Y-, and those coordinates in the 45000 range are preceded by 9990-Z-.

Appendix D.2. Location, time, tide stage, and sockeye salmon catch for all analyzed gill net drifts, Middle Bluff area stock identification test fishery, 1993.

Date	Time [a] High Tide	Time [a] Low Tide	Sample Area	Drift #	Time Fished	LORAN C Coordinates [b] Net In	LORAN C Coordinates [b] Net Out	Length (fathoms)	Mean Fishing Time (min)	Sockeye Salmon Catch	Index (CPUE)	Wind Direction	Wind Velocity (knots)
6/23	0552 1731	1221 2355	A	1	2230 - 2305	32560 and 45115	32529 and 45115	150	26.0	120	184.6	-	-
			D	1	2120 - 2220	32515 and 45115	32522 and 45119	150	48.0	123	102.5	S	0 - 10
6/24	0634 1835	1307 -	A	2	1100 - 1230	32554 and 45126	32564 and 45133	75	62.5	809	1,035.5		0
			C	1	1041 - 1238	32528 and 45111	32529 and 45110	150	78.0	800	410.3	S	0 - 15
				2	1340 - 1600	32531 and 45113	32523 and 45110	150	76.0	1000	526.3	S	0 - 15
				3	0630 - 0810	32523 and 45118	32538 and 45137	150	82.5	588	188.1		0
			D	2	0000 - 0003	32517 and 45136	32505 and 45128	150	90.0	225	100.0		0
6/28	0937 2254	0347 1622	A	3	1625 - 1805	32564 and 45130	32552 and 45129	150	55.0	1380	1,003.6	SE	15
				4	1816 - 1949	32560 and 45121	32560 and 45117	100	53.0	1250	1,415.1	SE	15 - 20
			D	1	1523 - 1827	32514 and 45108	32511 and 45115	100	121.5	1214	599.5	SE	20 - 25
				2	1622 - 1827	32517 and 45113	32511 and 45115	100	122.5	1500	734.7	SE	20 - 25
6/29	1028 2356	0449 1714	A	5	0242 - 0300	32553 and 45118	32553 and 45118	50	12.5	20	192.0	SE	10
				6	0841 - 0905	32562 and 45116	32563 and 45116	50	19.5	150	923.1	S	5
6/30	1121 -	0551 1807	A	1	1000 - 1301	32562 and 45123	32554 and 45123	150	148.5	479	129.0	SW	20
				2	1328 - 1415	32554 and 45119	32562 and 45124	100	38.0	61	96.3	SW	15

-Continued-

Appendix D.2. (p 2 of 2)

Date	Time [a] High Tide	Time [a] Low Tide	Sample Area	Drift #	Time Fished	LORAN C Coordinates [b] Net In	LORAN C Coordinates [b] Net Out	Length (fathoms)	Mean Fishing Time (min)	Sockeye Salmon Catch	Index (CPUE)	Wind Direction	Wind Velocity (knots)
7/06	0522	1137	A	1	1625 - 1652	32560 and 45114	32558 and 45112	75	25.0	122	390.4	SW	06 - 08
	1702	2317		2	1625 - 1709	32558 and 45112	32558 and 45112	50	41.5	275	795.2	SW	10
				3	1723 - 1807	32557 and 45127	32561 and 45127	100	40.0	141	211.5	SW	05 - 10
				4	1823 - 1913	32556 and 45135	32564 and 45138	100	46.5	128	165.2	SW	05 - 10
				5	1935 - 2117	32555 and 45111	32562 and 45120	50	160.0	611	458.3	SW	5
				6	2125 - 2151	32562 and 45123	32563 and 45123	75	22.5	175	622.2	SW	5
				7	2159 - 0036	32562 and 45125	32558 and 45122	100	153.5	1299	507.8	SW	05 - 10
			C	1	0926 - 1044	32526 and 45114	32533 and 45114	100	75.0	225	360.0	SW	10 - 15
				2	1646 - 1805	32535 and 45115	32535 and 45114	100	59.5	789	795.6	SW	5
				3	1632 - 1651	32533 and 45112	32531 and 45112	50	16.0	192	1,440.0	SW	-
				4	1652 - 1721	32531 and 45111	32527 and 45113	50	26.5	232	1,050.6	SW	-
				5	1723 - 1753	32529 and 45111	32530 and 45111	50	27.5	187	816.0	-	-
				6	1800 - 1843	32525 and 45109	32532 and 45113	50	37.0	220	713.5	-	-
7/08	0646	0006	A	1	1320 - 1405	32563 and 45120	32561 and 45119	100	25.5	570	1,341.2	SE	0 - 05
	1854	1311		2	1409 - 1445	32562 and 45122	32557 and 45119	50	32.0	270	1,012.5	SE	0 - 05
				3	2257 - 2318	32559 and 45122	32560 and 45122	50	18.0	83	553.3	SW	10
				4	2324 - 2347	32560 and 45123	32562 and 45123	100	21.5	125	348.8	SW	10
7/09	1724	0054	C	1	1657 - 1728	32535 and 45113	32530 and 45112	50	28.5	380	1,600.0		0
	1948	1353		2	1737 - 1832	32535 and 45116	32526 and 45111	50	53.0	315	713.0		0
			D	1	1847 - 2100	32515 and 45109	32514 and 45108	100	106.0	1200	679.2	SW	0 - 05
7/11	0835	0232	A	1	0330 - 0556	32565 and 45127	32555 and 45112	100	118.0	50	25.4	SW	12
	2133	1514		2	1050 - 1220	32555 and 45516	32565 and 45125	150	75.0	450	240.0	SW	8
				3	1245 - 1415	32555 and 45121	32564 and 45131	150	72.5	230	126.9	SW	6
				4	1523 - 1720	32561 and 45126	32554 and 45118	150	95.0	1000	421.1	SW	5
			B	1	0720 - 1020	32540 and 45126	32551 and 45123	150	138.0	180	52.2	SW	10

[a] Tide times are presented in military time (24 h clock) and were determined by using Nushagak District tide tables and the Middle Bluff, Kvichak Bay correction factors (e.g., high -0050, low -0050).

[b] LORAN C coordinates in the 32000 range are preceded by 9990-Y-, and those coordinates in the 45000 range are preceded by 9990-Z-.

Appendix D.3. Location, time, tide stage, and sockeye salmon catch for all analyzed gill net drifts, Middle Bluff area stock identification test fishery, 1994.

Date	Time [a] High Tide	Time [a] Low Tide	Sample Area	Drift #	Time Fished	LORAN C Coordinates [b] Net In	LORAN C Coordinates [b] Net Out	Length (fathoms)	Mean Fishing Time (min)	Sockeye Salmon Catch	Index (CPUE)	Wind Direction	Wind Velocity (knots)
6/26	0537	1155	A	1	0900 - 0945	32555 and 45119	32501 and 45123	150	33.0	68	40.0	ESE	5
	1727	2344		2	0954 - 1205	32555 and 45119	32565 and 45133	150	101.5	378	149.0	ESE	05 - 10
				3	1211 - 1403	32554 and 45125	32547 and 45124	150	84.0	403	191.9	ESE	10 - 15
6/27	0628	1250	B	1	1025 - 1050	32539 and 45120	32544 and 45123	150	20.0	7	14.0		0
	1831	-		2	1101 - 1209	32539 and 45132	32551 and 45138	150	61.5	47	30.6		0
				3	1224 - 1419	32539 and 45128	32539 and 45127	150	109.5	23	8.4		0
				4	1439 - 1540	32550 and 45132	32537 and 45124	150	54.0	66	48.9		0
				5	1602 - 1711	32550 and 45133	32537 and 45125	150	60.5	118	78.0		0
				6	1728 - 1804	32550 and 45129	32546 and 45126	150	30.0	22	29.3		0
				7	1810 - 1919	32543 and 45115	32544 and 45113	150	68.5	83	48.5	W	10
				8	1930 - 2045	32540 and 45120	32553 and 45123	150	51.0	56	11.0	W	10
			C	1	1807 - 1937	32525 and 45111	32526 and 45107	150	75.5	174	92.2	S	05
				2	1923 - 1948	32525 and 45115	32535 and 45119	150	46.0	142	123.5	S	05
				3	2114 - 2201	32525 and 45119	32535 and 45121	150	35.0	24	27.4	S	05
6/28	0716	0039	C	4	0932 - 1032	32525 and 45113	32535 and 45115	150	49.0	28	22.8	S	05
	1934	1341		5	1051 - 1210	32525 and 45114	32535 and 45116	150	70.0	22	12.6	S	05
7/01	0928	0323	D	1	1310 - 1329	32510 and 45113	32519 and 45120	150	33.5	394	470.4	E	35
	2233	1603		2	1420 - 1522	32511 and 45112	32519 and 45119	150	44.0	367	333.6	S	15 - 20
				3	1537 - 1736	32510 and 45118	32512 and 45120	150	78.5	1226	624.7	S	15 - 20
7/02	1009	0417	B	1	1237 - 1322	32540 and 45127	32548 and 45130	150	24.0	425	708.3	SW	20
	2327	1647		2	1337 - 1429	32540 and 45126	32549 and 45129	100	42.5	132	186.4	W	15 - 20
				3	1445 - 1550	32540 and 45124	32549 and 45128	150	53.0	190	143.4	SW	15 - 20
				4	1601 - 1731	32543 and 45132	32549 and 45131	150	68.5	450	262.8	SW	15 - 20
				5	1733 - 1843	32548 and 45130	32537 and 45122	75	56.0	268	382.9	SW	20 - 25

-Continued-

Appendix D.3. (p 2 of 2)

Date	Time [a] High Tide	Time [a] Low Tide	Sample Area	Drift #	Time Fished	LORAN C Coordinates [b] Net In	LORAN C Coordinates [b] Net Out	Length (fathoms)	Mean Fishing Time (min)	Sockeye Salmon Catch	Index (CPUE)	Wind Direction	Wind Velocity (knots)
7/10	0439	1059	A	1	1645 - 1825	32554 and 45117	32566 and 45128	150	65.0	1268	780.3	-	-
	1557	2230		2	1843 - 2018	32554 and 45116	32565 and 45127	150	82.0	420	204.9	-	-
			C	1	1250 - 1446	32535 and 45112	32525 and 45110	150	88.5	1766	798.2	S	05
				2	2037 - 2228	32525 and 45109	32529 and 45116	150	72.0	1045	580.6	S	05
				3	2301 - 0054	32533 and 45112	32527 and 45111	150	78.5	1002	510.6	S	05
			D	1	0940 - 1039	32512 and 45121	32516 and 45123	150	42.5	286	269.2	N	05
				2	1044 - 1205	32521 and 45131	32522 and 45133	150	68.5	163	95.2	N	05
				3	1214 - 1327	32523 and 45125	32512 and 45119	150	64.0	119	74.4	N	05

[a] Tide times are presented in military time (24 h clock) and were determined by using Nushagak District tide tables and the Middle Bluff, Kvichak Bay correction factors (e.g., high -0050, low -0050).

[b] LORAN C coordinates in the 32000 range are preceded by 9990-Y-, and those coordinates in the 45000 range are preceded by 9990-Z-.

APPENDIX E

Stock Identification Models

Appendix E.1. Stock identification model developed for age-1.3 sockeye salmon sampled from Kvichak, Naknek, Egegik, and Ugashik Rivers, 1992.

Actual Group Of Origin	Sample Size	AGE-1.3 Classified Group of Origin (%)		
		Kvichak-Ugashik[a]	Naknek	Egegik
Kvichak-Ugashik[a]	200	72.5	18.0	9.5
Naknek	196	21.9	69.4	8.7
Egegik	198	11.1	6.6	82.3

[a] The model could not differentiate fish from these two rivers based on scale pattern analysis, therefore these samples were combined.

Mean classification accuracy = 74.7%

Variables used: 2, 67, 11, 99, 19

Appendix E.2. Stock identification model developed for age-2.2 sockeye salmon sampled from Kvichak, Naknek, Egegik, and Ugashik Rivers, 1993.

Actual Group Of Origin	Sample Size	AGE-2.2 Classified Group of Origin (%)		
		Kvichak-Naknek[a]	Egegik	Ugashik
Kvichak-Naknek [a]	199	63.3	15.6	21.1
Egegik	198	18.7	76.3	5.1
Ugashik	200	18.0	4.5	77.5

[a] The model could not differentiate fish from these two rivers based on scale pattern analysis, therefore these samples were combined.

Mean classification accuracy = 72.4%

Variables used: 64, 35, 8, 71, 27, 88

Appendix E.3. Stock identification model developed for age-2.2 sockeye salmon sampled from Kvichak, Naknek, Egegik, and Ugashik Rivers, 1994.

Actual Group Of Origin	Sample Size	AGE-2.2 Classified Group of Origin (%)		
		Kvichak-Naknek[a]	Egegik	Ugashik
Kvichak-Naknek [a]	200	73.0	11.5	15.5
Egegik	200	21.5	73.0	5.5
Ugashik	196	14.3	4.6	81.1

[a] The model could not differentiate fish from these two rivers based on scale pattern analysis, therefore these samples were combined.

Mean classification accuracy = 75.7%

Variables used: 2, 69, 51, 27, 76, 44, 60, 18, 25, 23

APPENDIX F

Stock Composition by Area and Date, 1992-1994

Appendix F.1. Stock composition of sockeye salmon caught in the Naknek-Kvichak District stock identification test fishery, 1992.

Area	Date(s)	Percent Classification By Stock				Daily Abundance Index
		Kvichak-Ugashik	Naknek	Egegik	Total	
A	6/28	38.3	45.5	16.2	100.0	100.2
	7/01	61.8	38.2	0.0	100.0	66.5
B	6/21-6/25	54.4	45.6	0.0	100.0	13.4
	6/26	56.3	43.7	0.0	100.0	222.4
	7/01-7/02	74.3	25.5	0.1	100.0	371.4
C	6/21-6/25	90.9	7.9	1.2	100.0	31.4
	7/01-7/10	42.5	52.7	4.8	100.0	104.0
D	7/10-7/12	31.7	68.3	0.0	100.0	144.4
E	7/08	30.9	69.1	0.0	100.0	155.3
F	6/24-6/26	58.9	25.7	15.4	100.0	74.0
	6/28-7/01	66.5	32.6	0.9	100.0	71.7
G	6/25-7/02	59.9	30.2	9.9	100.0	432.6
	7/09	63.1	25.4	11.5	100.0	149.1

Appendix F.2. Stock composition of sockeye salmon caught in the Middle Bluff area stock identification test fishery, 1993.

Area	Date	Percent Classification By Stock					Daily Abundance Index
		Kvichak	Naknek	Egegik	Ugashik	Total	
A	6/24	13.9	7.8	78.3	0.0	100.0	610.1
	6/28	12.4	6.7	80.9	0.0	100.0	626.5
	7/06	6.2	2.4	86.0	5.4	100.0	450.1
	7/08	21.7	8.7	69.0	0.6	100.0	814.0
	7/11	8.1	4.0	79.0	8.9	100.0	203.3
B	7/11	10.1	5.8	64.3	19.8	100.0	52.2
C	6/24	10.7	7.8	81.5	0.0	100.0	374.9
	7/06	14.6	5.7	79.7	0.0	100.0	862.6
	7/09	7.9	2.3	83.7	6.1	100.0	1,156.6
D	6/23	10.3	7.7	82.0	0.0	100.0	101.3
	6/28	9.8	6.7	83.5	0.0	100.0	667.1
	7/09	6.1	2.4	86.0	5.5	100.0	679.2

Appendix F.3. Stock composition of sockeye salmon caught in the Middle Bluff area stock identification test fishery, 1994.

Area	Date	Percent Classification By Stock					Daily Abundance Index
		Kvichak	Naknek	Egegik	Ugashik	Total	
A	6/26	2.6	0.5	96.9	0.0	100.0	127.0
	7/10	3.7	0.7	95.6	0.0	100.0	492.6
B	6/27	4.6	1.0	94.3	0.0	100.0	33.6
	7/02	23.4	5.1	71.5	0.0	100.0	336.8
C	6/27-6/28	18.2	3.8	77.9	0.0	100.0	55.7
	7/10	1.6	0.3	98.2	0.0	100.0	629.8
D	7/01	38.9	7.8	53.3	0.0	100.0	476.2
	7/10	56.7	13.8	25.5	4.0	100.0	438.8